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ABSTRACT

This study tested 148 preschoolers between the ages of 48 and 72 months on a Piagetian number conservation task. Children's judgment accuracy, estimation, and response latency were measured. Children were also questioned about the number conservation principle. A four-step developmental sequence was hypothesized: (1) nonconservation; (2) correct judgment without adequate explanation; (3) correct judgment with adequate explanation after extra questioning; and (4) correct judgment and adequate explanation without probing. Some children fell into each of the four groups. Children who made correct judgments and provided adequate explanations only after additional questioning constituted 7 percent of the sample. These children were called "late explainers." Those who never gave adequate explanations, called "transitionals," constituted 16 percent. Half the transitionals and nonconservers were given a training session and were retested 2 weeks later. In the posttest, transitionals had no advantage over nonconservers, and students with training had no advantage over those who did not. Three references are included. (BC)

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PRESCHOOLERS' USE, UNDERSTANDING,
AND EXPLANATION
OF THE
NUMBER CONSERVATION PRINCIPLE

by

Linda Tollefsrud-Anderson, Ph.D.

paper presented

at the

SOCIETY FOR RESEARCH IN CHILD DEVELOPMENT

Baltimore, Maryland

April 24, 1987

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ABSTRACT

One hundred and forty-eight preschoolers were tested on a Piagetian number conservation task, with measures of judgment accuracy, estimation, and response latency, and with added questions about the number conservation principle. Two intermediate groups of children were identified, as well as conservers and nonconservers. "Late explainers" provided adequate explanations only after additional questioning. This group constituted 7% of the sample. "Transitionals" never gave adequate explanations, but were assumed to be using the number conservation principle because of the accuracy and speed of their judgments. Transitionals made up 16% of the sample.

Half of the transitionals and half of the nonconservers were given a training session designed to encourage adequate explanations. The training was expected to benefit the transitional children more, but a posttest given two weeks later showed no advantage of transitionals over nonconservers, or of training over no training.

This research suggests that a) methodological changes should be made in the conservation paradigm in order to ascertain clearly how much number knowledge children have; and b) developmental theories need to explain the lag between correct judgments and adequate explanations.

AIMS

The attainment of the Piagetian concept of conservation is a fascinating development because -- among other things -- it is "discovered" by preschoolers rather than being explicitly taught. A bevy of studies has not succeeded in specifying exactly how children learn and understand this concept, which marks the transition from pre-operations to concrete operational thinking. The present study was designed to provide a more fine-grained analysis of the development of number conservation through the description of intermediate stages, and to clarify the differences among the stages through the use of a short training task.

It was hypothesized that there would be several steps in the developmental sequence of preschoolers' ability to provide adequate explanations of the number conservation principle. This sequence was expected to proceed from (a) nonconservation; to (b) correct judgments, but no adequate explanations; to (c) correct judgments, but adequate explanations only after extra questioning; and, finally, to (d) correct judgments and adequate explanations without probing. It was also expected that the "transitional" (non-explaining) group would become full conservers after a short training session.

METHOD

In order to check for the possibility of intermediate groups, the following measures were taken: correctness of judgments, adequacy of explanations, observed estimation, and re-

sponse latencies. The response latency measure was a check for the use of covert estimation as a strategy. Overt estimation was noted to see if children were relying on observable counting or one-to-one correspondence procedures in their solutions.

Three numerosities, ranging from small (3) to large (20), were used to insure that subitizing could not be used to solve all of the problems. Twelve trials were included to reduce the probability of being consistently correct by merely guessing. Also, addition and subtraction trials at each numerosity served to rule out a "same" response bias.

Additional questions were asked of each child who did not readily provide an adequate explanation. This served to differentiate between those who promptly explained the number conservation principle and those whose initial level of performance was, for whatever reason, less than their competence.

Half of the transitionals and half of the nonconservers received a short training session 1 to 7 days after the pretest; the untrained children in these groups served as controls. The training trials were designed to emphasize both what does and what does not change number, and to give each child a chance to actively participate by counting. Both adequate and inadequate explanations were modeled to avoid having children succeed on the posttest by simply parroting the experimenter's words. One to two weeks after training, a posttest was administered by a different experimenter.

SUBJECTS AND MATERIALS

Complete data were collected on 148 preschool children ranging in age from 48 to 72 months. There were 65 males and 83 females.

The pretest stimuli were balls of yarn attached to elastic strips. The numerosities used were 3, 6, and 16, with four trials at each numerosity. The first trial at each numerosity was an addition trial, the second and third were conservation trials, and the fourth was a subtraction trial.

The posttest stimuli were similar to those of the pretest, except that the arrays were of 3, 8, or 20 buttons. The training-task stimuli were arrays of small plastic figures.

RESULTS

On the basis of the pretest, children were divided into four groups. "Conservers" (Group 1) readily provided at least one adequate explanation on a conservation trial. "Late explainers" (Group 2) articulated an adequate explanation on a conservation trial only after additional questioning. "Transitionals" (Group 3) gave consistently correct judgments in a short amount of time, but never adequately explained. "Nonconservers" (Group 4) did not give an adequate explanation on any conservation trial (and thus could not be in Group 1 or 2), and were either incorrect, had long response latencies, and/or overtly estimated on more than one trial (and thus could not be in Group 3).

Sixty-one children were classified as Group 1 on the pretest, 10 as Group 2, 24 as Group 3, and 53 as Group 4. The mean ages of these groups were 62.4, 61.6, 60.2, and 58.1 months, in that order. Subjects were assigned randomly to either Condition A or Condition B, resulting in the design illustrated below.

Pretest Performance	Condition	Number of Subjects
Group 1 (conservers)	A - no posttest	28
	B - posttest, no training	33
Group 2 (late explainers)	A - no posttest	3
	B - no posttest, no training	7
Group 3 (transitional)	A - posttest, training	11
	B - posttest, no training	13
Group 4 (nonconservers)	A - posttest, training	22
	B - posttest, no training	31

On the posttest, 51 subjects met the criteria for Group 1 membership, 4 for Group 2, 23 for Group 3, and 39 for Group 4. These classifications were made independently of the pretest data. The mean ages for these posttest groups were 61.1, 61.7, 59.4, and 57.4 months, respectively.

Due to the small number of subjects in Group 2, especially on the posttest, Group 2 was not included in most analyses. However, the performance of these subjects was not significantly distinguishable from Group 1 or Group 3 subjects on the basis of their judgments or response latencies.

Pretest-posttest analysis. To examine changes from pretest to posttest that were not related to training, the no-training subjects (Condition B) in all three developmental groups were

examined. A chi-square model-fitting procedure was used. This procedure (Thomas, 1977; Thomas, 1980) requires that the hypothesis that the pretest and posttest data are independent be rejected, then different theoretical models are compared to the observed data. The hypothesis of independence was rejected (Pearson chi-square = 16.41, 6df, $p < .025$). The four models tested include (1) a "no-learning" model, (2) an "all-or-none" model, (3) a "one-stage progression" model, and (4) a "one- or two-stage advance" model. The models used and the results of these analyses are included in Figure 1.

Insert Figure 1 about here

The no-learning model, which specifies that subjects will not change their classification from pretest to posttest, may be rejected, since it is the worst fit to the data and it approaches statistical significance. The other three alternatives are all acceptable, but the best fit is achieved by the one-or-two stage advance model. This model suggests that Group 3 represents a stage that children are in only briefly, if at all. This model might be characteristic of a theory which suggests that transition involves disequilibrium, an undesirable state.

The pretest-posttest results indicate that there is change, even in the absence of training. The percentage of children showing regression is 15% for Group 3 and 12% for Group 1; the percentage advancing is 39% for Group 4 and 46% for Group 3.

Training analysis. The effects of training were evaluated using the same model-fitting technique. A Pearson chi-square

Figure 1.

Pretest-Posttest Analysis

		NC ₁	T ₁	C ₁
OBSERVED	NC ₂	19	2	1
DATA	T ₂	6	5	3
	C ₂	6	6	29

Gp 4 = NC = nonconservers

Gp 3 = T = transitional

Gp 1 = C = conservers

1 = pretest } subscripts

2 = posttest

TYPE OF MODELDIAGRAMEXPECTED FREQUENCIES

		NC ₁	T ₁	C ₁
no	NC ₂			
learning	T ₂			
model	C ₂			

		NC ₁	T ₁	C ₁
NC ₂	20.5	3.3	3.3	
T ₂	3.3	5.4	3.3	
C ₂	3.3	3.3	31.3	

$\chi^2 = 9.03, 5 \text{ df}$
 $p \approx .10$
 model rejected

		NC ₁	T ₁	C ₁		
all-or-none	NC ₂				NC ₁	T ₁
learning	T ₂				19.0	3.0
model	C ₂				3.0	5.0
					6.0	6.0

$\chi^2 = 5.00, 3 \text{ df}$
 $p \approx .25$
model not rejected

one-stage

learning

model

	NC ₁	T ₁	C ₁
NC ₂		X	X
T ₂			X
C ₂	X		

	NC ₁	T ₁	C ₁
NC ₂	19.0	3.0	3.0
T ₂	6.0	5.0	3.0
C ₂	3.0	6.0	29.0

$\chi^2 = 4.66, 3 \text{ df}$

$p \approx .25$

model not rejected

		NC ₁	T ₁	C ₁																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														</
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test for independence was performed, and the hypothesis of independence was rejected ($\chi^2 = 38.65$, 6 df, $p < .001$). The observed data, theoretical models which were tested, and resulting χ^2 values are presented in Figure 2.

Insert Figure 2 about here

As in the pretest-posttest analysis, the no-learning model assumes that subjects will make no changes in their classification. This model, again, yields a χ^2 value large enough to allow for its rejection.

The differential learning model tests the original hypothesis that training would promote a change to adequate explanations (conservation) for Group 3 subjects who were trained, but be ineffective for Group 4 subjects, trained or untrained. The resulting χ^2 value for this model indicates that it is statistically acceptable.

An opposing model, which also provides an acceptable fit, specifies that children in both groups are more likely to advance if they are not trained. This "cognitive-conflict" model proposes that a training session causes children to rethink their hypotheses regarding number concepts, leading to a temporary state of disequilibrium and to poorer performance. However, the best-fitting model is again the one- or two-stage learning model. This model assumes that learning is taking place in the weeks between the pretest and posttest regardless of training and that change can be either one or two steps in the direction of better

Figure 2.

Training Analysis

OBSERVED

DATA

	NC_1^*	NC_1^o	T_1^*	T_1^o
NC_2	15	19	2	2
T_2	2	6	5	6
C_2	5	6	4	5

Gp 4 = NC = nonconservers

Gp 3 = T = transitionals

Gp 1 = C = conservers

* = trained

° = not trained

1 = pretest

2 = posttest

} superscripts

} subscripts

TYPE OF MODELDIAGRAMEXPECTED FREQUENCIES

no

learning

model

	NC_1^*	NC_1^o	T_1^*	T_1^o
NC_2			X	X
T_2	X	X		
C_2	X	X	X	X

	NC_1^*	NC_1^o	T_1^*	T_1^o
NC_2	17.6	22.3	3.0	3.0
T_2	3.0	3.0	5.9	7.1
C_2	3.0	3.0	3.0	3.0

 $\chi^2 = 11.16$

7 df

 $p \approx .10$

model rejected

predicted

model --

differential

learning

	NC_1^*	NC_1^o	T_1^*	T_1^o
NC_2			X	X
T_2	X	X		
C_2	X	X		X

	NC_1^*	NC_1^o	T_1^*	T_1^o
NC_2	16.8	21.2	3.2	3.2
T_2	3.2	3.2	5.6	6.7
C_2	3.2	3.2	4.4	3.2

 $\chi^2 = 6.59$

6 df

 $p \approx .50$ model not
rejected

cognitive

conflict

model

	NC_1^*	NC_1^o	T_1^*	T_1^o
NC_2			X	X
T_2	X			
C_2	X		X	

	NC_1^*	NC_1^o	T_1^*	T_1^o
NC_2	15.4	19.5	2.7	2.7
T_2	2.7	6.2	5.1	6.2
C_2	2.7	6.2	2.7	5.1

 $\chi^2 = 3.16$

4 df

 $p \approx .50$ model not
rejected

one- or two-

stage learning

model

	NC_1^*	NC_1^o	T_1^*	T_1^o
NC_2			X	X
T_2				
C_2				

	NC_1^*	NC_1^o	T_1^*	T_1^o
NC_2	15.0	19.0	1.9	1.9
T_2	2.0	6.0	5.0	6.0
C_2	5.0	6.0	4.0	5.0

 $\chi^2 = .005$

1 df

 $p \approx .95$ model accepted
model is very
close fit

performance.

While the predicted model (differential learning) was statistically acceptable, it was not the best-fitting one, and the opposing model could not be rejected. Since roughly equal proportions of children in both the training and no-training conditions advanced on the posttest, and since the best-fitting model does not differentiate between trained and untrained subjects, it would be most parsimonious to assume there was no real effect of the training session.

CONCLUSIONS

The existence of Group 2 and 3 subjects has been confirmed by this study, although it appears that Group 2 subjects are quite rare. The existence of Group 3 subjects indicates that Brainerd (1973) was at least partially correct in his argument in favor of the correct-judgments-only criterion. The fact that these transitional children go through a period in which they appear to use the conservation principle but cannot (or choose not to) provide adequate explanations suggests that such a period should be included in descriptions of number conservation learning.

The training part of this study was designed to more clearly identify the experiences that might move children from Group 3 to Group 1 or 2, and thus to more clearly specify the differences between these groups. There were, however, no clear differential effects of training. Group 3 children appeared to be equally likely to advance whether or not they were trained, and they did

not show significantly more developmental advance than did Group 4 subjects. There is a possibility that the additional questioning that was done in the present study promoted a kind of disequilibrium for Group 4 as well for Group 3 subjects, and that the training session did not add appreciably to the cognitive conflict already induced by the pretest.

It is not clear whether Group 2 and 3 represent universal stages. It seems likely, from the high rate of change from pretest to posttest, that either these transitional periods are very short ones, or that they are not characteristic of all children. A longitudinal study with more frequent testing might shed some light on this question. It would also be informative to look for the presence of these transitional periods on other kinds of conservation tasks.

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